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Landscaping Considerations for Urban Stream Restoration Projects

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Complexity	*Environmental Value*	*Cost*
Low Moderate High	Low Moderate High	Low Moderate High

OVERVIEW AND PURPOSE

Many restoration projects are implemented in urban environments, where the landscape and environmental conditions have been sufficiently altered that true restoration aimed at achieving "natural" functions is limited and the reconstruction of pre-impact form is impossible. Under these circumstances, and in many cases where such constraints do not exist, the success of a project – as viewed by the public – is often based largely on the visual appeal of the site after restoration and its functionality for public use.

The landscaping component of such stream and riparian restoration projects must be emphasized given its importance of visual success and public perception. The purpose of this technical note is to address landscaping considerations associated with urban stream and riparian restoration projects, and provide ideas to managers for enhancing the visual appeal and aesthetic qualities of urban projects.

Attention to landscaping details for urban stream restoration projects can:

- Improve environmental awareness.
- Offer recreational opportunities.
- Provide privacy and noise control.
- Enhance visual appeal.
- Accentuate or diminish adjacent land uses.
- Minimize maintenance.
- Increase value of real estate.

LANDSCAPE DESIGN PRINCIPLES

Landscape design principles include unity, balance, sequence, proportion, rhythm, accent, repetition, and variety to create the composition of the design. Color, line, form, mass, texture, scale, light, and time are visual elements used in combination that create interest. This interplay of design principles and visual elements yields a design for a specific site that fulfils the intended purpose of the design.

PRINCIPLES

Unity means that all parts of the composition or landscape go together; they fit. Everything selected for a landscape must complement the central scheme and serve some functional purpose. Unity is obtained by effectively using the components in a design to express a main idea through consistent style and to harmonize the whole.

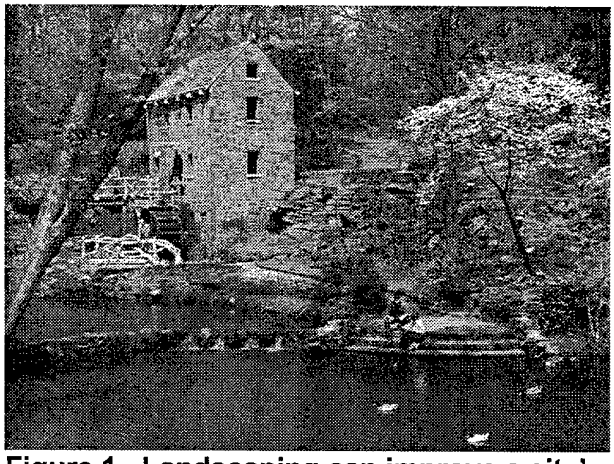

Figure 1. Landscaping can improve a site's visual appeal and recreational potential

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Balance in design refers to the equilibrium or equality of visual attraction. Symmetrical balance is achieved when one side of the design is a mirror image of the other side. Asymmetrical balance uses different elements of interest on either side of the central axis to obtain balance and visual attraction. For example, mass may be opposed by color.

Sequence is a successive change of visual perspectives or spatial transition as one moves through a series of spaces. For example, this transition can be obtained by the arrangement of objects with varying textures, forms, or other elements in a sequential order assisting the gradual movement of the viewer's eye through the designed area. Or it can be a progression of spaces created by combinations of plants, earth, and structure creating interest and leading one through the area.

Proportion refers to the size of parts of the design in relation to each other and to the design as a whole. A 3-ft vernal pool, for example, would be lost in a large open greenway but would fit beautifully into a small opening along a path in a riparian corridor. Proportion in landscape architecture usually refers to the human scale, relating a person to the built environment.

Rhythm is achieved when the elements of a design create a feeling of motion leading the viewer's eye through or even beyond the designed area. Elements like color schemes, line, and form can be repeated to attain rhythm in landscape design. Rhythm reduces confusion in the design and creates a pattern through the designed area.

Accent involves bringing attention to a feature by simplifying the elements around it in space. For example, line can be used to direct visual observation toward a feature as the focal point. In painting or the built environment the color red is often used as a focal point, to aid the eye in its travel through a canvas or along a route.

Repetition refers to the repeated use of features like plants with identical shape, line, form, texture, and/or color. Too much repetition creates monotony but when used effectively can lead to rhythm or can bring attention to an accent. Unity can be achieved by repetition of the same element, simplifying by elimination of other elements and unnecessary detail.

Variety can provide interest and diversity in the landscape. A flower garden is a simple example of a designed space reflecting variety, and a riparian forest is a diverse natural environment. Biodiversity is associated with the health of a system or natural landscape. In the design of a naturalized landscape or restoration project, replication of the variety of associated plants growing in that environment would aid in restoring function to the area.

ELEMENTS

Color can be used to change perspective. Warm colors and light tints like red, orange, yellow, and white advance an object or area toward the observer. Cool colors and deep shades like blue, green, and black recede and can be used to make objects appear further away. Designers use color to direct attention in the landscape and create a path for the eye to follow. Light colors and tints tend to attract attention, as do bright, vivid colors. Color as an element can strongly influence the emotions and mood. Cool colors are restful, while warm colors express action and excitement.

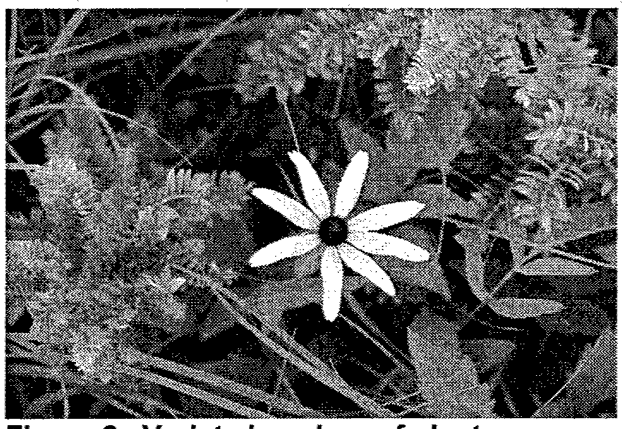

Figure 2. Variety in colors of plants or structural elements can enhance the visual appeal of the restoration site

Line moves the eye visually or the person physically through space. It can be used to create patterns. In the urban landscape, line is inferred by linear features such as streams, riparian corridors, paths and trails, roads and other infrastructure, which aids in navigating

through a space. Horizontal lines generally elicit a restful feeling while vertical lines create a feeling of energy. Straight lines tend to be forceful, structural, and stable and direct the observer's eye to a point faster than curved lines. Curved or free-flowing lines are smooth and graceful and can be used to create a natural feeling.

Form can be described as a shape or structure of an object or space. For example, form can be discussed in terms of individual plant growth habits describing their shape. Plant forms include oval, ball, egg, columnar, cylindrical, pear, vase, spire, mound, and cushion. The branching character of a plant creates the structure which can be described as ascending, arching, spreading, weeping, or irregular.

Mass is the combination of a group of objects to create perceptions, such as a solid plane or a specific pattern. Qualities of mass can be heavy, dense, soft, light, or thin. Plants can be grouped to create three-dimensional space. For example, plants amassed in a woodland or buffer create horizontal and vertical planes or spaces. The canopy or overstory is experienced as a ceiling, elements of the understory such as the shrub layer are experienced as a wall, and ground covers consisting of grasses and herbaceous plants can be interpreted as a floor.

Texture describes the surface quality of an object that can be seen or felt. Qualities of texture can be smooth, rough, glossy, or dull. Perspective can be created by using materials with different textures to create the sensation of greater depth. A coarse texture can be used in the background, medium texture is used in the middle, and fine texture is used in the foreground. A glossy texture reflecting light will jump out in the foreground, whereas a dull texture recedes.

Scale refers to the size of an object or objects in relation to the surroundings. Size refers to definite measurements while scale describes the size relationship between adjacent objects. A small scale defines larger areas and conversely a larger scale defines a smaller space. In an urban environment where there are tall buildings adjacent to a stream restoration project, people are attracted to the restoration area in part because the area is at a human scale compared to the surrounding buildings.

Light and shade create a visual pattern in the environment. Light comes forward and shade recedes in perspective. This interplay of light and shade adds visual interest in the landscape. The interplay of light and shade can be an environmental consideration in design. For example, maximize efficient heating by utilizing solar radiation and cooling by using vegetation to shade an area. Organisms have various tolerances to the amount of light they receive, and this must be considered in the stream restoration project design to allow organisms to live in the area. Plants must be selected to survive in the light condition present at a particular location. Day and night light variations can be used in design to extend interest. For example, in the sun white flowers and silver plants will brighten any color around them and are visible at night, particularly in moonlight.

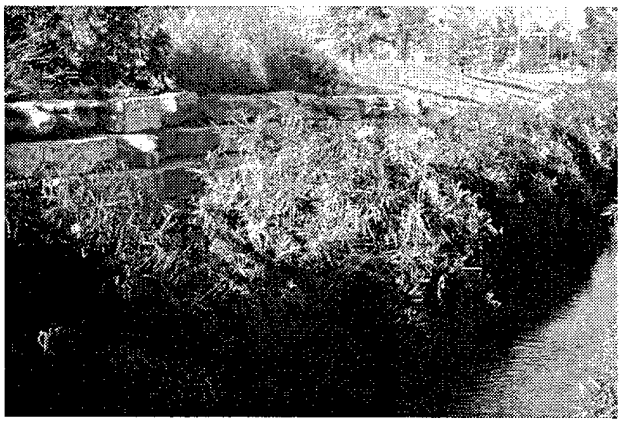

Figure 3. Elements of mass, form, and texture can be combined to create an appealing perspective

Time can be expressed by the seasonal changes or diurnal rhythms. Interest in the landscape can be achieved by adding elements that have different characteristics at different times of the year. For example, deciduous and evergreen plants can be used for different purposes in a planting design. Plant response to seasonal variation can include flowering, fruiting and foliage color changes that can be utilized by the designer to add interest to the landscape.

THE DESIGN PROCESS

The design process is one of continual change based on information, refining the design until all the pieces work efficiently together and function as a whole. There are several steps and products defining the design process for a landscape design. These are an assessment of needs and constraints, a site analysis of existing conditions, the development of a site plan, planting plan, and grading plan and developing site details and specifications. With the design information bound into a contract, a design can be implemented by a contractor. Once construction is complete and the built environment exists, monitoring and maintenance requirements can aid in determining if the design has been successful.

ASSESS NEEDS AND CONSTRAINTS

The client and community using a particular place will determine the needs and constraints of the design. To be successful, a design must respond to needs and constraints. In addition to the ecological objectives that normally accompany restoration projects, the designer is responsible for addressing safety, health and welfare for all participants using the designed area.

Safety can include consideration of flood control measures, erosion control, bank stabilization, and pedestrian safety in an urban stream restoration project. Appropriate sizing of the channel is an important aspect for flood reduction. Erosion problems need to be identified, thus enabling design solutions to be developed. Stabilization of streambanks may be necessary to provide a safe environment. All public recreational areas and facilities need to be accessible and comply with the Americans with Disabilities Act (ADA) for the safety of the public using the area. This includes walkways, picnic areas, or other site amenities, parking lots, and signage used within the project. Signage, lighting, and appropriate fencing and railings may be necessary site amenities to provide for a safe pedestrian experience.

Health considerations include water quality and environmental enhancements. Identifying environmental problems with hazardous, toxic, radioactive waste (HTRW) surveys and water testing may be necessary if the site location is in old urban fabric or the area is being impacted by adjacent uses. Plants can be selected to aid in the remediation of an area and improve the water quality. Vegetative buffer strips, corridors, and greenways are all ecosystem enhancements that perform a number of these functions. Plant diversity within these areas will improve the environment and allow for more wildlife to utilize the area.

Welfare of the public is also considered in looking for opportunities to provide various recreational activities, visual interest, and value to the adjacent land uses. Respite can be found along the corridor by active and passive forms of recreational activities. The stream and associated greenway can provide views into the area and offer a visual break from the surrounding urban fabric. Adjacent property values will increase due to the amenities provided by the stream restoration project.

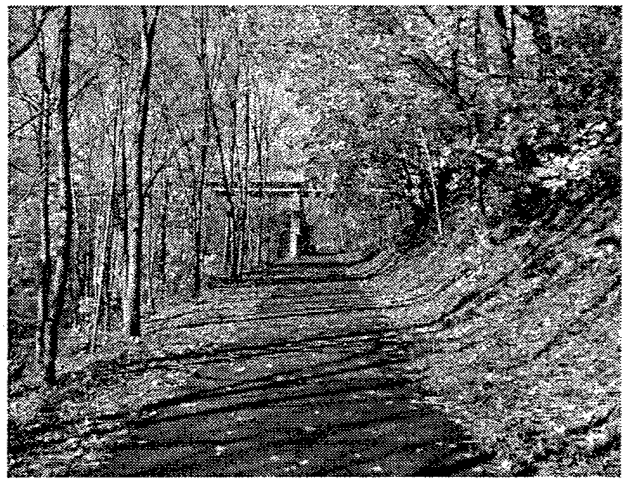

Figure 4. Multi-use trails in urban environments can provide recreational opportunities and increase land value

A thorough site analysis

A complete survey of the project site is essential and can save time and money. It should include existing vegetation, landforms, soils, hydrology, views, migration routes for wildlife, and transportation corridors, and location of all structures (both onsite and adjacent to the stream corridor) should be documented and mapped. Climatic considerations to note are aspect, solar gain, rainfall distribution, seasonal wind pattern, and micro-climatic conditions.

Existing plants should be examined. Tree, shrub, and groundcover names, locations, and condition should be recorded. Trees on adjoining property that would affect shade patterns on the site should also be surveyed. This information is essential to designers, as it is their responsibility to blend the project into the natural or existing setting and create a functional setting that complements the restoration activities for the stream. Saving existing plants for the stream restoration project will require protecting them during the construction process. It may be desirable to block vehicular traffic from areas close to valuable trees. Care must be taken not to change the existing grade by either adding soil or compacting soil in the area under the drip line of a tree.

Figure 5. Survey the existing landscape to identify vegetation and features that should be retained or used in the design

Land form refers to slope or land elevation changes. It determines surface water drainage patterns and is essential knowledge for the development of a functional grading plan and aesthetically pleasing landscapes. Any landform that is unique, such as a waterfall, can add to a stream restoration project. Changes in elevation can provide opportunities to provide views into and out of the site. The knowledge of depth to bedrock is also an important consideration. Slope aspect should be considered because solar gain or cooling affects plant establishment.

Soil pH, nutrient characteristics, water holding capacity, and drainage should be considered for the site. Existing plants can be clues about the soil condition. For example chickweed (*Stellaria media*), daisy (*Chrysanthemum leucanthemum*), dock (*Rumex crispus.*), and plantain (*Plantago major.*) are likely to grow in acidic soils, whereas lambsquarters (*Chenopodium album*) and the mustard family often grow in alkaline soils. Plants may also indicate poorly drained soils, in which plants will grow that can tolerate wetter soils. Plants can also indicate a lack of specific nutrients and fertility. For example, Lupines (*Lupinus spp.*) and clover (*Trifolium spp.*) grow in nitrogen-deficient soils. A simple examination of the soil by digging a hole can determine its texture, depth of topsoil, and other soil horizons. Soil maps prepared by the Natural Resource Conservation Service (formerly the Soil Conservation Service) will give specific information on soil classification and potentials of the soil. For more in-depth knowledge of the soil, testing the soil from various locations on the site will indicate pH and chemical composition. Recommendations for nutrients and lime additions can then be made for the intended plant types (or crops) to be grown.

Hydrology and the condition of the existing stream corridor should be assessed. The timing, frequency, magnitude, and duration of flows in the stream influence the makeup of the riparian community, affect aquatic organisms, and influence the stability of constructed features. Water quality, turbidity, temperature, and underlying substrate can all affect the dissolved oxygen levels. Water elevations, slopes and velocities at various discharges, and the frequency, duration, timing, and rate of change of those discharges, are elements in determining stream forms and riparian communities. Quantifying these characteristics contributes information to the successful restoration process for the health of aquatic organisms and communities.

Manmade environmental aspects to be considered in planning and design include noise levels, transportation and utility corridors, property ownership, property lines and easements, surrounding land use, existing buildings and their architectural style, and proposed ingress and egress to accomplish construction and maintenance. Laws and zoning ordinances can determine permits that may need to be obtained. Zoning and design ordinances determine the guidance on setbacks, which usually do not apply to plants. However, easements for electric lines and gas lines will restrict the plant

growth and can introduce concerns regarding herbicide usage.

Climatic considerations such as rainfall distribution can be determined on a regional basis. Periods of heavy rainfall can magnify the problems of shallow soils or a hardpan resulting in unwanted standing water. Predominate wind directions differ with the region, the season, and the time of day. Where the wind direction differs in summer and winter, plantings can be arranged to block the cold winter winds from a public use area and direct summer breezes into this same area. All of these factors interact to create microclimates, and conditions in an isolated spot may differ considerably from the conditions in another area of the landscape. The designer must consider those variations in order to "fine-tune" the landscape plan and plant selection.

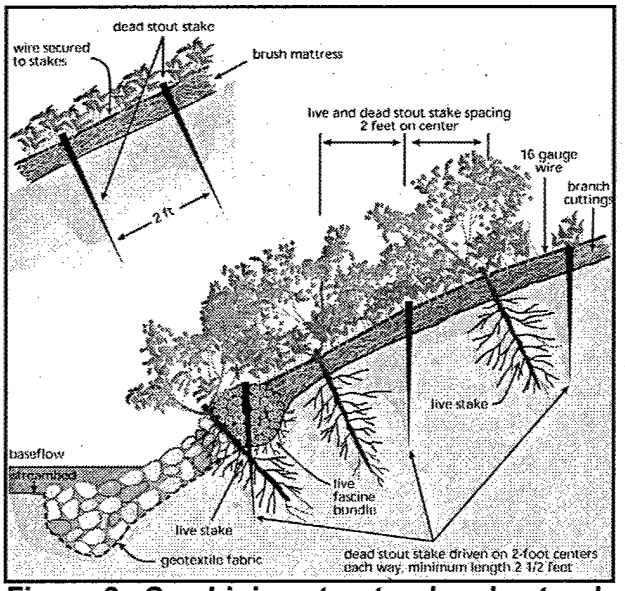

Figure 6. Combining structural and natural elements into functional restoration measures is the keystone of good landscape design

DEVELOP A SITE PLAN

This will combine the information gathered in the site analysis with the programmatic elements of the needs and constraints. All plans include standard conventions such as a north arrow for orientation, a bar scale, and a title block indicating the name of the project, client, who did the design, and the date. An appropriate scale will be chosen to depict the dimension of

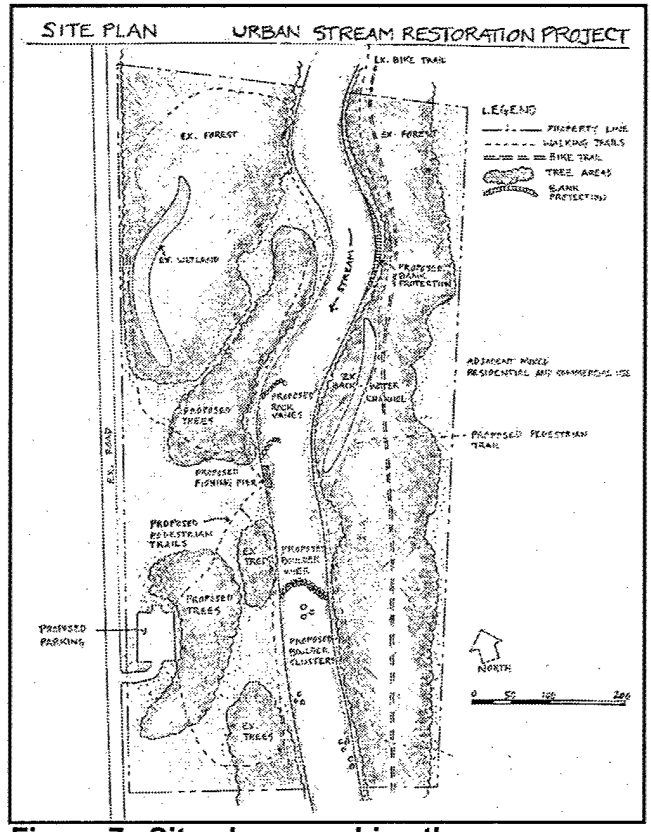

Figure 7. Site plans combine the programmatic elements with the site analysis data to fulfill the needs and functions of the proposed project

elements in a one-to-one unit relationship, visually represented in a way that is easily interpreted by anyone using the plan. If there is a need for a more detailed area, another plan at a different scale can be produced for that specific area. Match lines are also graphic conventions if the site plan is on more than one sheet. This will likely be the case for urban stream restoration projects involving linear corridors.

Property boundaries, easements, rights of way and utilities are indicated by various styles of lines in plan view. Existing vegetation, buildings and other features can be shown with a lighter line weight. The proposed features can be drawn with a heavier line and labeled as proposed, for clarity. Access roads, walkways or trails, streams and any other existing hydrologic feature are to be shown and noted. Proposed recreational features, seating and signage may be elements added to the site plan. Adjacent land uses around the site should be noted so that the

design will be compatible with the surrounding properties. Notes can be added to clarify the proposed elements or anything of importance that is not graphically represented on the plan. Specifications will contain detailed product information and define the process through which the plan will be built.

DEVELOP A PLANTING PLAN

The values of landscape plants are many, including their influence on climate, air purification, erosion control, noise reduction, privacy screening, and increasing property value. Plants are important to the microclimate because they absorb heat from the air during the transpiration process (release of water in the form of vapor), provide shade that reduces solar radiation and reflection, lower wind speed, disperse fog, and influence snow deposition.

Businesses have noted that attractively landscaped buildings result in above-average labor productivity, lower absenteeism, and easier worker recruitment. Studies have indicated that people have a basic desire for contact with plants. Satisfying this need can have a strong positive influence on human behavior. Providing a planted buffer or greenway along a stream restoration project will have a positive effect on humans and wildlife within the urban environment.

The planting plan incorporates the existing plants to be preserved with the plants to be planted. Plant selection is based on the specific needs identified in the site analysis and site plan. In developing a planting plan, it is important to meet the site criteria and needs such as utilizing plants to provide windbreaks, shade, privacy, and noise screening, or to satisfy other objectives. The plan should address the total site. In a stream restoration, the planting plan will be within the property boundary of the project. The plant selection process should consider factors such as mature size of the proposed plants, adaptability to local soil and precipitation conditions, exposure to light conditions, wind, hardiness zones (based on annual low temperatures) and maintenance requirements. Plant texture, foliage color, flowers, and fruit during various times of the year may also be important considerations. Existing invasive species are problematic and may require eradication for the success of a restoration project. Using plants that are native or naturalized to the environment will increase the native wildlife adapted to live in the area.

The planting plan will have the standard plan conventions; it will depict areas of existing vegetation labeled as such and plants proposed to be planted labeled with a number or code that is further defined in a key. The key is a table on the plan with plants indicated by the number or code, followed by the Botanical name (Latin genus and species), the common name, the size and how the plant is to be purchased. There may be a block for notes on the plan. Other specific information will be found in the specifications on how to perform the planting.

DEVELOP A GRADING PLAN

A grading plan is a separate plan noting the existing contours and indicating the proposed contours that are to blend into the existing contours on the site. Natural site drainage features and any manmade drainage structures are indicated as existing. The proposed drainage features are indicated and labeled. The correction of any erosion problem is addressed in this plan. In the case of a stream restoration project, various existing or proposed bank protection treatments will be noted. Handicapped accessibility requires grading of designed features and spaces according to the Americans with Disabilities Act and design guidance (U.S. Access Board 1998).

DEVELOP SPECIFIC SITE DETAILS

After the preferred alternative is selected, it is a good idea to review the project objectives to determine if minor modifications can improve the project's environmental function. Dardeau and Fischenich (1995) modified a design for a flood control project to incorporate environmental features into the design, saving $16M in project costs by reducing mitigation requirements through the relocation of borrow pits, levee realignment, modified interior drainage, and incorporation of habitat features into the design. Specific site details can have a major impact upon the overall functionality of the project.

Locate public activity areas, including areas for both passive and active activities. For example, passive usage can be views into the area from off- and on-site, seating, and picnic tables for relaxation. The activity areas can be trails, boardwalks, stream access points for boat launching and fishing, and open areas for play.

Kiosks can provide a formal entrance into a natural area informing the visitors of any information that may make their visit to the area more meaningful, fun, and safe. Wildlife viewing can be accommodated on site by a path system that is away from vehicular traffic and other high-use areas. Nature trails can be developed using interpretive signage. In a stream restoration project a path system can be developed following the stream corridor in a vegetated buffer along the shoreline. Overlooks can provide visual enjoyment for all using the area. The style of signage can help unite the area within the project bounds and may reflect the style of other signage used by the sponsor, such as an urban park commission.

Biotechnical planting utilizes plants in specifically designed features to retain earth and prevent soil loss. This method can be used with plants as the main component or in combination with other earth retaining structures to create attractive, cost–effective, and environmentally compatible solutions to slope stability. Both biological and structural elements must function together in an integrated and complementary manner. This can be an effective tool in an urban stream restoration project. Techniques can include contour wattling, brush layering, brush matting, and live staking, which utilizes indigenous plants. Plants are chosen for their ability to produce adventitious roots that can become established relatively quickly to provide a root mat that holds the earth together and prevents erosion. Biotechnical slope protection systems are generally more labor-skill intensive than energy-capital intensive, allowing them to be useful in projects that have limited funding.

Instream and streambank structures are used in stream restoration projects to stabilize the channel or banks, or to improve habitat. Streams in urban environments are commonly incised, so structures that prevent degradation are often needed. Many techniques and structure types can be employed to achieve these objectives. From a landscaping perspective, it is important to select the techniques (or use the materials) that best meet the project's architectural requirements. Table 1 lists a number of structures that can be used for various purposes. Other technical notes in this series detail these measures.

Table 1. Environmental features for channel and streambank protection

If you wish to:	*Consider using:*
Prevent degradation of the streambed	Boulder weir structures or constructed riffles
Maintain or improve terrestrial riparian habitat value	Reinforced revetment, toe protection, bank sloping and revegetation, vegetation, stream corridor management, fencing and buffer strips, or floating plant construction
Provide stable substrate for benthic macro-invertebrates	Riprap or quarry run stone, gabions, or hard points
Provide or maintain fish habitat	Tree revetments, earth core dikes, hard points, tree retards
Improve or maintain aesthetic resources	Vegetation, combinations of vegetation and structures (composite revetment, coir logs, earth core groins, excavated bench, and revegetation of riprap), fencing and buffer strips, selective clearing
Provide access to stream for recreation and/or wildlife	Composite revetment, berm preservation and restoration, bank sloping and revegetation, channel relocation, revegetation of riprap, or stream corridor management

Riparian corridors and greenways are linear strips of vegetation adjacent to streams and rivers. A greenway can be a vegetated strip along any corridor or protected open space linking one area to another spatially. This linkage can be an important design feature for human use, and even more critical for wildlife. In an urban stream restoration the greenway provides different functions, such as protecting water quality by acting as a filter strip and protecting streambanks from erosion, enhancing wildlife habitats, and creating a movement and dispersal corridor. They can play critical long-term roles as floodways. Linking the stream restoration project to a park or other natural area, connecting it to a network of greenways, or reconnecting areas of fragmented habitat, maximizes the potential of the greenway for wildlife usage. It can also provide opportunities for various recreational activities by creating walking or biking trails. Greenways enhance the communities of which they are a part, enriching the quality of life by providing recreational opportunities, improving aesthetics, and increasing property values.

In an urban stream restoration project there may be a limited amount of land available for the width of the greenway on both sides of the stream and existing incursions of conflicting land uses along the linear run of the project. However, the designer can utilize the principles and elements of design and vegetative assemblages to create plans that compensate for disturbances and look for opportunities to make linkages. Generally, the greenway should be a combination of native herbaceous plants, shrubs and trees. Planting a diversity of plants that would naturally occur in the native plant community if it were undisturbed is desirable. A healthy environment is usually the one with the greatest diversity of plant and animal life. Providing a diverse planting plan that accommodates differing site conditions, aspects, and elevations can allow for the creation of various habitats.

Seed mixes composed of a variety of grasses, sedges, and other herbaceous plants will offer plants with different life histories. Shrub and tree seed can also be put into the mix. Primary succession occurs when early pioneer species colonize mineral substrates or undisturbed soils. Secondary succession occurs as the dominant vegetation reclaims an area after disturbance. The restoration project seeks to restore successional change at some stage and allow the community to grow to a climax community. The planting plan can jump-start the succession process to allow for the development of a more diverse and healthier environment that restores function to the stream and its corridor.

SITE MAINTENANCE

Project success is determined after construction. A monitoring period can record the development of the restoration effort over time. Are the design features functioning as intended? Does the site use the existing resources in an effective way? Does the project meet the needs of the client and community within budget? Public surveys can indicate if the usage of the site, recreational facilities and aesthetics fulfill the needs and provide a positive experience for the user.

Stability of the physical structures can be monitored for signs of erosion occurring around buildings and pathways, or along the stream channel and by repairing areas in failure before problem areas become more pronounced. Additionally high flow events should be recorded to observe impacts and alterations to the in-stream structures. Vandalism to any features on the site must be addressed for public safety. The circulation system should be observed for vehicular and pedestrian safety. Conflicts between user groups need to be resolved.

Botanical survey information can indicate successional changes of the site over time. Replanting may be required if there is a lack of cover (less than 70 percent cover is a general guideline). However, succession will occur and wild plant seed will come into an area to supplement the planting plan, particularly if tracts of existing vegetation were to be preserved on site.

Maintenance should be as low-cost and efficient with as little energy use as possible. Mowing and herbicide usage should not be a realistic management approach if the goal is to restore the natural function of the urban stream. Succession should be the goal for planted restored areas, although there may be exceptions to this. One exception is the eradication of invasive species within the restoration corridor. Careful application of a systemic herbicide by hand by a specialist who can identify the invasive plant

may be acceptable. No widespread spraying of herbicides or pesticides is acceptable because the risks and ramifications to the environment are too great. Mowing a path or open spaces intended for recreation may be acceptable. The use of low maintenance groundcovers and seed mixes would probably be more in keeping with shrinking maintenance budgets. There is beauty in a naturalized grass and wildflower planting and a great opportunity to educate the public to appreciate the difference.

CONCLUSION

A successful urban stream restoration project can improve the communities' environmental awareness, while offering recreational opportunities. The vegetative buffer can provide privacy, noise control, bank stabilization, aesthetics, and increase real estate values and wildlife habitat. For managers, it provides a low maintenance opportunity to utilize an urban stream that otherwise may not have been viewed as a valuable component of the landscape.

The community's involvement in the design, construction, and monitoring of the restoration may be a measure of project success. This may serve as a possible model for other areas that need restoration within the urban fabric. The first step is learning and caring about the difference the restoration can make. This one action can extend to any other greenway, other public open spaces, or private spaces. Schools can become involved in the restoration process and academic curriculum can be formulated as part of the process. Every restoration project is an opportunity to improve the environmental quality for all that live there and a chance for all of us to restore something valuable into the fabric of our lives.

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